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BEFORE THE
SUBCOMMITTEE ON OVERSIGHT AND
INVESTIGATIONS
OF THE
COMMITTEE ON ENERGY AND COMMERCE

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Mr. Chairman, and members of the Committee. My name is Michael Mann. I am an associate professor in the Departments of Meteorology and Geosciences at Penn State University, and Director of the Penn State Earth System Science Center. My research involves the use of climate models, the analysis of empirical climate data, and developing methods for comparing observations and model predictions. The primary focus of my research is understanding the long-term behavior of the climate system, including key climate processes such as the El Nino/Southern, and determining the roles of various potential agents of climate change, both natural and human.

I have served as organizing committee chair for the National Academy of Sciences *Frontiers of Science*, and as the co-author or advisor for several National Academy of Sciences panels related to climate change. I served as a member of the *Committee on Probability & Statistics* of the American Meteorological Society for three years. I have also served as editor for the *Journal of Climate* of the American Meteorological Society and have served as a member of numerous other international and U.S. scientific working groups, panels and steering committees. I have co-authored more than 70 peer-reviewed articles and more than 30 other peer-reviewed contributions and book chapters on climatology and paleoclimatology.

In my testimony here today, I would like to emphasize the following key points:

1) Numerous independent studies using different data and different statistical methods have re-affirmed the most important conclusions of the work my colleagues and I began more than a decade ago. All published studies show that late 20th century average Northern Hemisphere warmth appears to be unprecedented over at least the past 1000 years. Several studies now suggest this holds over an even longer timeframe.

2) *Our main conclusions have recently been endorsed by an expert non-partisan report issued by the U.S. National Academy of Sciences (NAS) just weeks ago. The NAS endorsed our conclusion that the late 20th century Northern Hemisphere average warmth was likely anomalous in the context of at least the past 1000 years. “Likely” means having a slightly better than even probability --- i.e., a probability of roughly two-thirds. (See 2001 IPCC Report). In their press conference, the authors of the NAS report stated that they too believe a roughly two-thirds probability can be attached to this conclusion. The NAS report also noted that our conclusions are supported by multiple independent studies and independent lines of evidence.*

3) *The precise details of our early work have been independently reproduced and confirmed by climate scientists Dr. Eugene Wahl and Dr. Caspar Ammann based on the data used in our study and the algorithm descriptions that have been available in the public domain for years. This work also confirms that my co-authors and I fully adhered to scientific standards by making our data available to other researchers.*

4) *Climate scientists are not a close-knit “social” group that engages in group think. Hundreds of scientists work in this field and we are a competitive bunch. We compete for scarce research dollars, academic recognition, and professional standing. Every scientific publication that my colleague or I have published has been subject to rigorous and independent peer review. Peer review in my field is anonymous. Authors play no role in selecting peer reviewers. And it is quite possible --- indeed likely --- that a journal will select someone who has expressed skepticism in one’s work as a peer reviewer.*

5) *The evidence for human-induced climate change does not rest solely or primarily on paleoclimatic evidence generally, or on my work in particular.*

In order to understand the work that my colleagues and I have performed, it is important to locate it within the larger body of climate studies. Prior to our work in the late 1990s, few scientists had attempted to undertake a detailed spatial reconstruction of the climate during prior centuries, and associated errors were basically unquantified. For that reason, scientists had to rely on cartoon-like schematics, much like the one presented in the 1990 IPCC report. By the mid 1990s, researchers had recognized that it was possible to attempt a more rigorous, quantitative reconstruction of past climate using proxy climate data. Our study was just one of several studies in the late 1990s which attempted to produce such a quantitative reconstruction of past large-scale temperature changes. It was considered by many to be the most comprehensive reconstruction because of its emphasis on spatial patterns of past change, and our quantitative estimation of uncertainties. In the words of the NAS, our work was “groundbreaking.” As a result, a number of assumptions had to be made with little guidance available from past work. It was for that reason that our 1999 *Geophysical Research Letters* article describing our reconstruction of Northern Hemisphere temperature changes over the past millennium was titled “Northern Hemisphere temperatures during the past millennium: inferences, ***uncertainties, and limitations.***” (Emphasis added). The article also emphasized both the caveats and uncertainties involved, and the tentativeness of our conclusions. Indeed, the points of our study that have engendered the most interest --- that the 1990s were likely the warmest decade ever; and that 1998 was likely the warmest year in the past millennium --- were all presented as tentative conclusions (e.g., “likely” which, by IPCC standards, means having a roughly 2/3 probability of being correct), not as categorical or unequivocal findings.

Our work is hardly out of the mainstream. The paleoclimate reconstruction studies published by my co-authors and I in the late 1990s represented just one of many independent studies which came to similar conclusions. Our studies represented a significant advance in the field at the time primarily because they provided estimates of spatial patterns of temperature change, something that is of equal or greater scientific interest than simply the average temperature of the Northern Hemisphere. Our study was also the first to attempt to estimate uncertainties. It was unfortunate that only our reconstruction was shown in the 2001 IPCC *Summary for Policy Makers* (SPM) which is far more widely read than the Scientific Assessment report. While I was a co-author of chapter 2 of the Scientific Assessment report, I had no authorship or editorial involvement with the SPM. In chapter 2 of the Scientific Assessment report, three different paleoclimate reconstructions were shown. Each of these reconstructions supported the conclusion that late 20th century Northern Hemisphere average warmth was likely unprecedented as far back as reconstructions were performed, which, in two cases, dated back 1000 years.

Since the publication of our original work in the late 1990s and the publication of the 2001 IPCC report, numerous other Northern Hemisphere average temperature reconstructions have been published in peer-reviewed journals. Each of these reconstructions, using different sets of proxy data (in some cases which are entirely independent of the data we used) and different statistical methods, come to the same key conclusion: That late 20th century warmth is likely anomalous in the context of at least the past 1000 years (see exhibit A). In fact, recent studies extend this conclusion to at least the past 2000 years. See Moberg A, Sonechkin DM, Holmgren K, Datsenko NM,

Karlen W. 2005. Highly variable Northern Hemisphere temperatures reconstructed from low and high-resolution proxy data. *Nature* 433: 613-617.

At the time my collaborators and I published our original studies, there were no existing methods of combining diverse proxy data to reconstruct past spatial temperature patterns. Our results, as discussed further below, have proved robust. In the decade since our original calculations were performed, new proxy climate records have been developed, statistical methods for reconstructing climate from proxy data have been refined, new methods for using synthetic climate proxy data derived from simulations have been tested, and detailed comparisons between proxy reconstructions and independent estimates from theoretical climate models have been conducted. All of this is aimed at better understanding the workings of the climate system.

I have been actively engaged in these research activities. For more than five years, my collaborators and I have been developing and applying alternative methods that represent a significant refinement to our original methods. We have shown that these methods are not subject to the criticisms that have been raised regarding our original work (*see, e.g.,* Mann, M.E., Rutherford, S., Wahl, E., Ammann, C., Testing the Fidelity of Methods Used in Proxy-based Reconstructions of Past Climate, *Journal of Climate*, 18, 4097-4107, 2005) and yet they yield results essentially indistinguishable from those reported in our original work. *See* Rutherford, S., Mann, M.E., Osborn, T.J., Bradley, R.S., Briffa, K.R., Hughes, M.K., Jones, P.D., Proxy-based Northern Hemisphere Surface Temperature Reconstructions: Sensitivity to Methodology, Predictor Network, Target Season and Target Domain, *Journal of Climate*, 18, 2308-2329, 2005.

The report by Wegman, et al., looks only at our earliest work. Wegman's report does not look at any of our more recent studies, or the work of dozens of other climate

scholars. That omission is striking because these researchers have found the same basic “hockey stick” temperature history. Nonetheless, Wegman’s report does not examine whether the use of statistical conventions he suggests undermine our original work have been employed in more recent work by my co-authors and me, or of the other climate scientists engaged in reconstruction work. Whatever merit one assigns to Wegman’s criticisms, they go to the first, and necessarily most tentative, of all of the reconstruction data and ignore the enormous amount of diverse and sophisticated work that has followed.

For this reason, the narrow focus of the Wegman report misses the point. The “hockey stick” is not simply an isolated or aberrational finding my co-authors and I reached only once, in one study. On the contrary, it is a finding that every climate scientist who has performed a detailed examination of the available data has reached, because the hockey stick figure is driven by the data. The Wegman report does not acknowledge the key point made in the recent NAS report, namely, that many researchers have come up with the same basic “hockey stick” reconstruction (i.e., a reconstruction that is within the estimated uncertainties of the Mann et al reconstruction) based on the use of different proxy data sets or different statistical methods (see Exhibit A). Nor does the report acknowledge any of the work that my collaborators and I have been engaged in during recent years seeking to refine the original methods we developed a decade ago. These refined methods, unexamined by Wegman, et al., yield essentially the same result as our original methods, although they use different statistical techniques (see Exhibit B).

Moreover, Wegman has not been careful to represent our findings accurately. For instance, Wegman and his co-authors have stated in their report: *"Overall, our committee believes that Mann’s assessments that the decade of the 1990s was the hottest decade of*

the millennium and that 1998 was the hottest year of the millennium cannot be supported by his analysis.” We never made the sort of definitive statements attributed to us by Wegman. In the abstract of our 1999 article in *Geophysical Research Letters* we stated that “[w]e focus not just on the reconstructions, but on the uncertainties therein, and important caveats...expanded uncertainties prevent decisive conclusions for the period prior to A.D. 1400.” We concluded by stating that, “...more widespread high resolution data are needed before more confident conclusions can be reached...” It is hard to imagine how much more explicit we could have been about the uncertainties and limitations.

Perhaps the most serious omission in the Wegman report, however, is its failure to acknowledge that its central focus — the conventions used for centering in the Principal Components Analysis used to represent certain tree-ring proxy data — has no significant implications on the results of our analysis. The hockey stick pattern derives from the data, not in the PCA. Nonetheless, Wegman’s report claims that the PCA centering convention used to represent the North American tree-ring data network in our 1998/1999 studies is responsible for the “hockey stick” shape of our reconstruction. But the report’s conclusion does not follow from its premise. Even accepting that certain statistical conventions that were used in our original studies might not be optimal under some circumstances, the use of alternative conventions yields the same “hockey stick” figure. Nowhere does the Wegman report even acknowledge that its assertion that our reconstruction is a function of PCA centering conventions was *rejected* by the NAS. On page 116 of the NAS Report, the NAS notes that the PCA procedure used by Mann et al. “does not appear to unduly influence reconstructions of hemispheric mean temperature;

reconstructions performed without using principal component analysis are qualitatively similar to the original curves presented by Mann et al.”

I understand that Dr. Hans Von Storch made precisely this point at the previous hearing. That is not surprising. Even apart from the NAS, the contention that our initial PCA procedure is responsible for the “hockey stick” figure has been considered and rejected by *four independent teams* of scientists, including one led by Dr. Von Storch: (i) Huybers [Huybers, P. (2005), Comment on “Hockey sticks, principal components, and spurious significance” by S. McIntyre and R. McKittrick, *Geophys. Res. Lett.*, 32, L20705, doi:10.1029/2005GL023395], (ii) Von Storch and Zorita [Von Storch, H. and E. Zorita (2005), Comment on “Hockey sticks, principal components, and spurious significance” by S. McIntyre and R. McKittrick, *Geophys. Res. Lett.*, 32, L20701, doi:10.1029/2005GL022753], (iii) Wahl and Ammann (2006) [Wahl, E.R. and C.M. Ammann (2006), Robustness of the Mann, Bradley, Hughes Reconstruction of Surface Temperatures: Examination of Criticisms Based on the Nature and Processing of Proxy Climate Evidence, *Climatic Change* (in press); see website: http://www.cgd.ucar.edu/ccr/ammann/millennium/refs/WahlAmmann_ClimChange2006.html] and (iv) Rutherford et al (2005) [Rutherford, S., M.E. Mann, T.J. Osborn, R.S. Bradley, K.R. Briffa, M.K. Hughes, and P.D. Jones (2005), Proxy-based Northern Hemisphere Surface Temperature Reconstructions: Sensitivity to Methodology, Predictor Network, Target Season and Target Domain, *Journal of Climate*, 18, 2308-2329].

These studies are significant to the Committee’s work because each one shows that the PCA convention simply influences the relative ordering of the leading patterns of variance in the proxy data, and does not lead to the “hockey stick” shape of the reconstruction, nor does it have any significant influence at all on the details of the

reconstruction. Exhibit “C” taken from Wahl and Ammann (2006) (on which statistical climatologist Dr. Douglas Nychka was consulted) demonstrates what the Mann et al. (1998—“MBH98”) reconstruction looks like if the “centered PCA analysis” is used rather than the PCA convention of MBH98 and, if in addition, one of the less well replicated proxy series contested by McIntyre and McKittrick is removed from the data set. The result is basically the same “hockey stick” reconstruction as MBH98. In fact, if one does not use PCA to represent proxy data networks, and uses a completely different method (“RegEM”) to relate the MBH98 proxy dataset to modern instrumental patterns, again essentially the same reconstruction is observed (see Rutherford et al, 2005 referred to above). That is because, as I’ve said, the hockey stick pattern is in the data. Whether PCA is used, or how it is used, does not make any overall difference. PCA was simply used to encapsulate all of the statistically relevant information in the proxy data, and so whatever patterns are in the data will always influence the final reconstruction. Only when statistically significant information is removed from the dataset is a different result obtained.

The reconstruction work by other scholars like Wahl and Ammann also lay to rest any suggestion that my colleagues and I did not fully disclose our underlying data and therefore hindered replication of our work. Attempts by other climate scientists, such as Wahl and Ammann (2006), have successfully reproduced our results based entirely on our publicly available data and algorithmic descriptions. More significant than this, however, is the fact that numerous studies using different proxy data and methods, or using climate model simulations, have given essentially the same result as our original 1990s work.

Paleoclimate reconstructions produced by various groups, as specifically highlighted in the NAS report, are only one of many independent lines of evidence that have led the world's scientific community to reach a consensus that modern global warming is real and is, in large part, attributable to human activity. All of the climate scientists that testified in the earlier hearing agreed on that point. Greater attention needs to be paid to this pressing issue, including estimating the likely impacts of future climate change, and seeking solutions that will allow us to avert its most detrimental effects.

As climatology has become a more inter-disciplinary field the need for better communication between sub-disciplines and between observationalists, modelers and analysts has become clear. Steps that could facilitate this communication include improved funding for the world data centers so that more effort can be made on data recovery and archiving, and developing systems to ensure that data gatherers can be properly credited for data deposited in public archives.

Thank you.

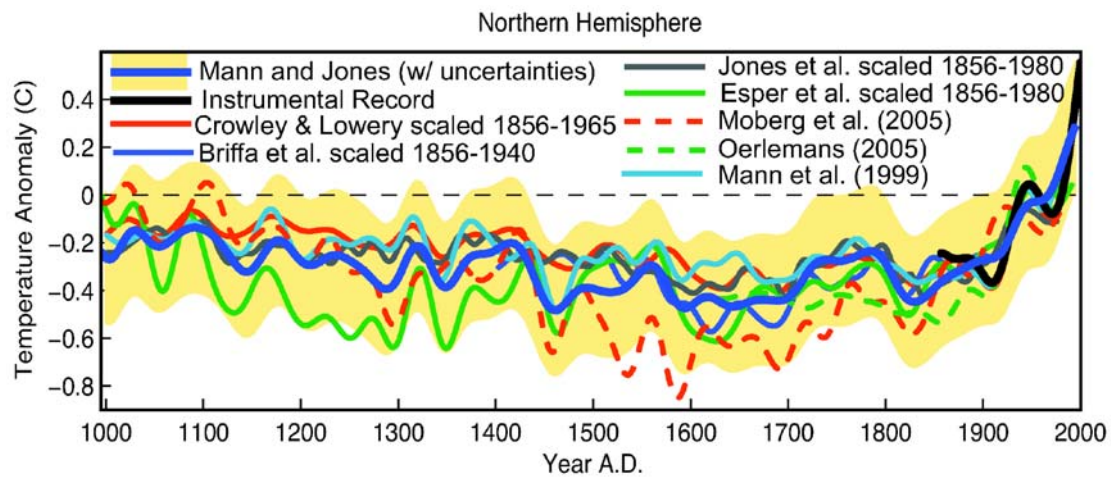


Exhibit A. Comparison of various different reconstruction of Northern Hemisphere average temperatures over the past 1000 years.

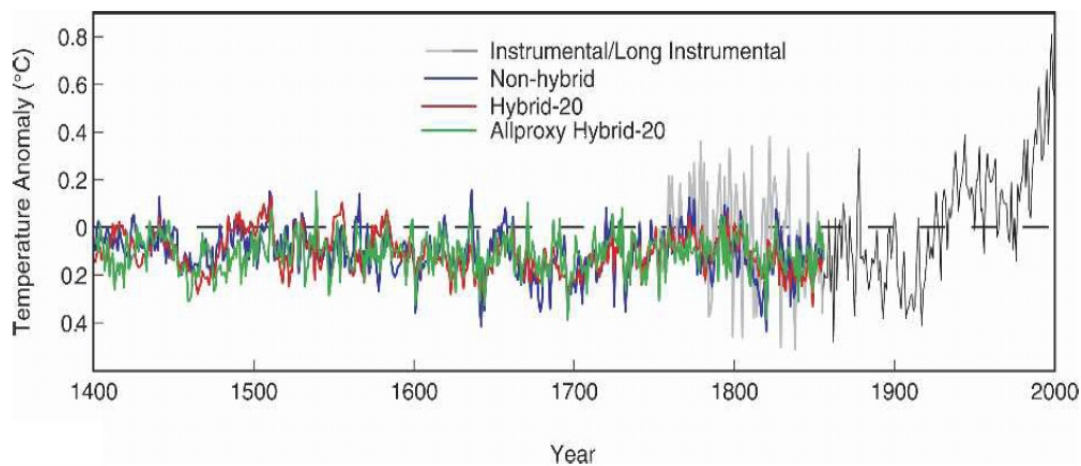


Exhibit B. [from Rutherford et al (2005), Figure 2]. Original MBH98 reconstruction (blue) compared against reconstruction (green) using original MBH98 proxy data set and alternative statistical method which does not represent proxy data with PCA at all.

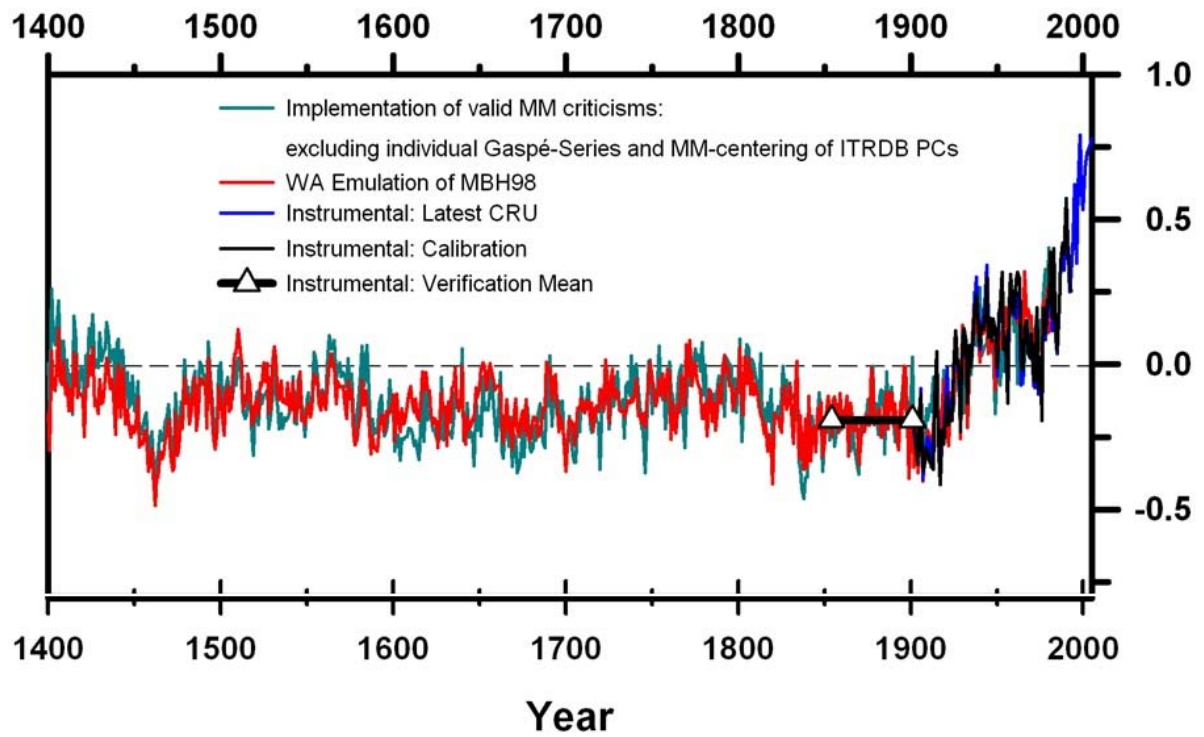


Exhibit C. [from Wahl and Ammann (2006), Figure 5d]. MBH98 reconstruction using centered PC analysis: Red is the original MBH emulation and green is the calculation using centered PC analysis (and additionally removing one of the less well replicated tree ring series).